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**NEWTOWN, CONNECTICUT**

REPORT NUMBER : B(I,II,III,IV),  
Nonr. 1126(00).

15 April, 1955.

**S E C T I O N I**

\*\*\*\*\*

**REPORT**

**on**

**OPERATIONAL FEASIBILITY TESTS  
OF "SKYHOOK" TECHNIQUE FOR IN-  
FLIGHT PICK-UP OF MEN AND MA-  
TERIALS WITH HIGH PERFORMANCE  
AIRCRAFT**

**under**

**OFFICE OF NAVAL RESEARCH  
CONTRACT Nonr. 1126(00)**

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**REPORT NUMBER** B (I,II,III & IV) Nonr. 1126(00).

**DATE** 15 April, 1955.

**SECTION I**

\*\*\*\*\*

**REPORT**

on

**OPERATIONAL FEASIBILITY TESTS  
OF "SKYHOOK" TECHNIQUE FOR IN-  
FLIGHT PICK-UP OF MEN AND MA-  
TERIALS WITH HIGH PERFORMANCE  
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**ROBERT E. FULTON, JR.      NEWTOWN,      CONNECTICUT.**

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THIS REPORT COMPILED BY

ROBERT E. FULTON, JR.

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REPORT No. B (I) Nonr. 1126(00). DATE 15 April, 1955. PAGE B.

REPORT TITLE HIGH-PERFORMANCE AIRCRAFT PICK-UP, SKYHOOK.

I N D E X, SECTION I.

S U B J E C T

P A G E

SECTION I

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\* Section IV is a 16mm kodachrome motion picture film taken during conduct of Operational Feasibility Tests at NAAS, El Centro, Calif.

## "SKYHOOK" TECHNIQUE

---

Assignment calls for development of a method by which IN-FLIGHT-PICK-UP of men and materials can be accomplished with high-performance aircraft.

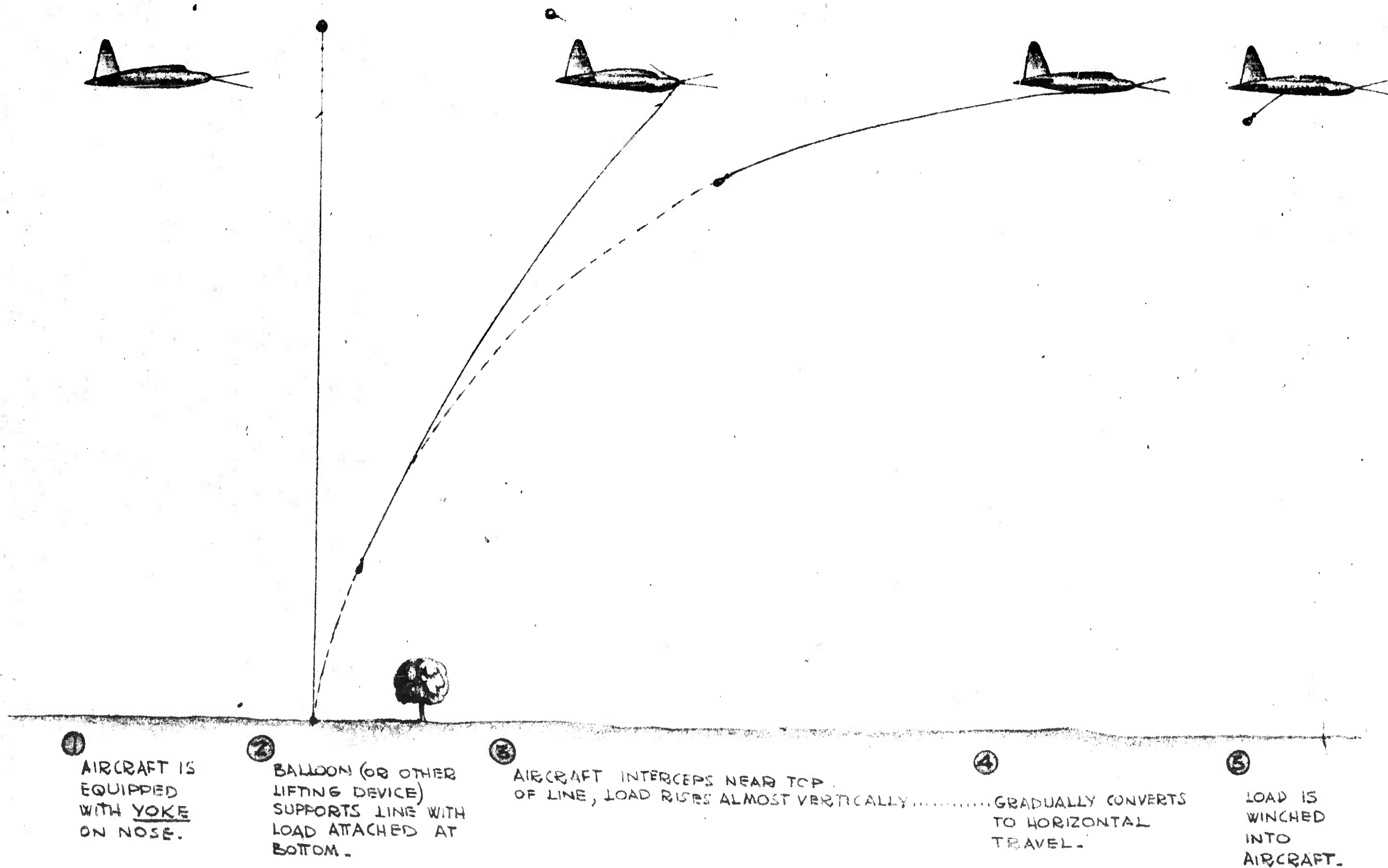
One such method is the SKYHOOK TECHNIQUE which works as follows:

1. Balloon (or other lifting device) supports top end of a line approximately 500 feet above ground.
2. Load is attached to bottom of line.
3. Aircraft intercepts near top of line with "yoke" mounted on nose.
4. Load rises almost vertically, gradually alters to horizontal travel.
5. Load is winched into aircraft.

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REPORT TITLE HIGH-PERFORMANCE AIRCRAFT PICK-UP,  
"SKYHOOK" TECHNIQUE.



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REPORT No. B (I) Nonr.1126(00). DATE 15 April 1958 PAGE 3.

REPORT TITLE HIGH-PERFORMANCE AIRCRAFT PICK-UP, SKYHOOK.

#### PURPOSE OF REPORT

This Report deals with tests conducted to prove feasibility of this technique.

Three separate test programs have been successfully conducted to date:

1. Initial tests with Contractor-owned and operated very small aircraft and light loads to prove basic theory.
2. "Safety tests" with somewhat larger Contractor-owned and operated aircraft, heavier loads and higher speeds to study motions of picked up load and top end of line to determine if any danger to aircraft might exist when conducting tests with large, higher speed operational equipment.
3. Preliminary large-scale feasibility tests conducted at NAAS El Centro, California, with full scale Navy owned and operated equipment and heavy loads.

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REPORT TITLE HIGH-PERFORMANCE AIRCRAFT PICK-UP, SKYHOOK.

## RESULTS

All three of these programs have been successfully conducted, the final one achieving the following standard of results:

- \* Aircraft: P2V
- \* Intercept speed: 125 knots
- \* Loads picked up: up to and including 300 pounds.
- \* Average G's imposed on load: 7.54 (Minimum 5, maximum 10.2).
- \* Duration of maximum G's:  $\frac{1}{2}$  second.
- \* Minimum altitude of pick-up aircraft need never be below 400 feet.
- \* Pick-up path of load would clear 100 ft. high obstacle less than 100 feet away.
- \* No problem encountered intercepting the lift-line with large, operational type aircraft.

In all more than 50 successful pick-ups were accomplished during all three phases of testing.

# OPERATIONAL PHOTO SEQUENCE

Accompanying pictures were taken during operational  
feasibility testing at NAAS El Centro, illustrate a  
typical pick-up operation .....



RENDEZVOUS

(P2V)

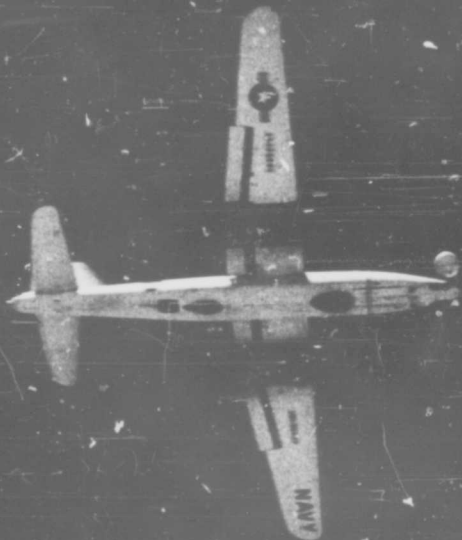
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APPROACH

(500 foot altitude)



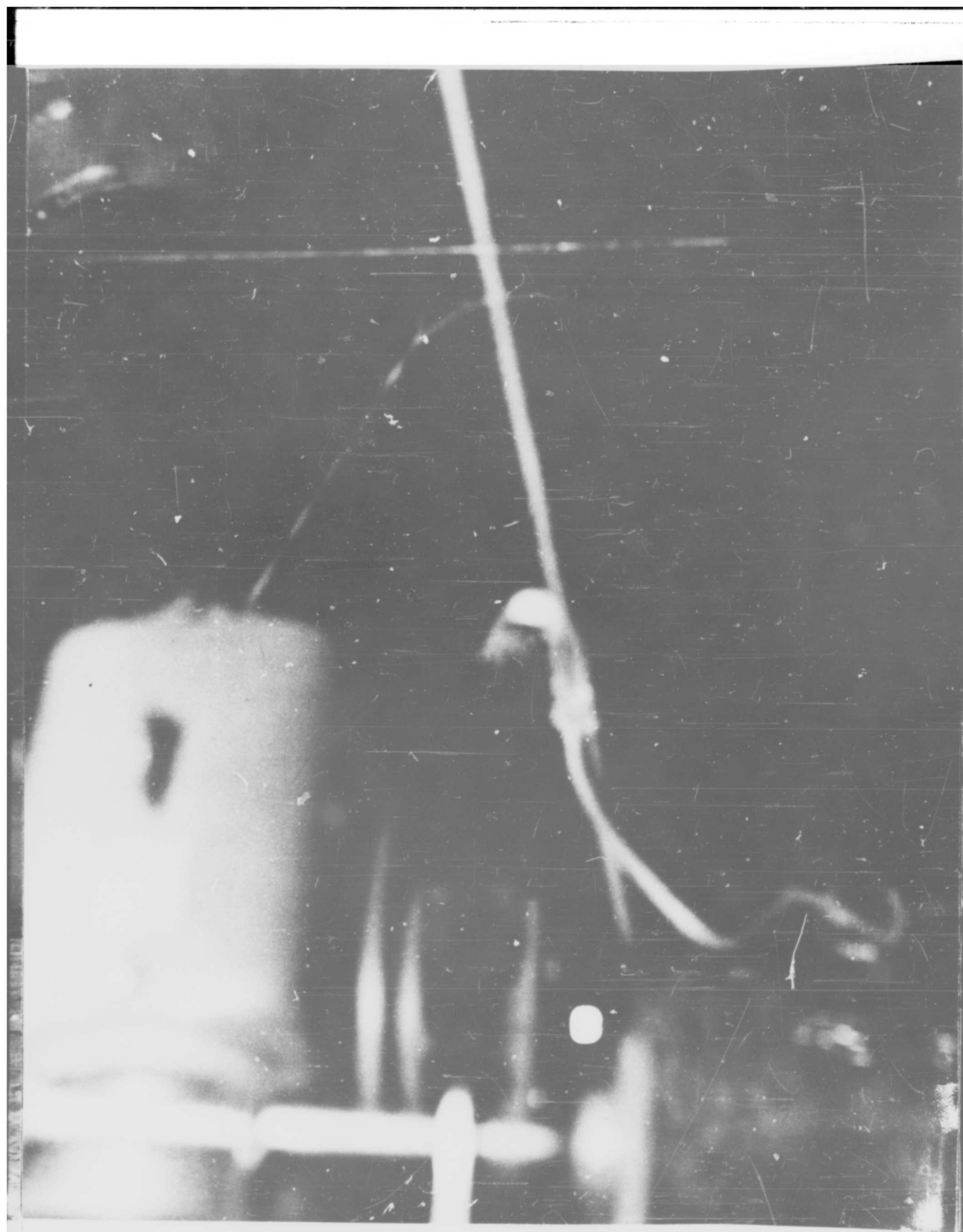
INTERCEPT

(125 knots)



"LOAD AWAY"

(300 pounds)




HAUL IN

(1½ minutes)



ABOARD



RETURNING TO BASE

(Up to 2,000 miles)

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**TYPICAL PICK-UP PATH OF LOAD**

---

Accompanying typical curve is taken directly from  
motion picture film recording path of 200 pound  
load picked up with 500 foot lift-line at aircraft  
speed of 125 knots .....



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REPORT TITLE HIGH-PERFORMANCE AIRCRAFT PICK-UP, SKYHOOK.  
LOAD PICK-UP PATH FROM MOTION PICTURE.

HORIZONTAL DISTANCE FT

100

200

500'

1 BALLOON

FLIGHT PATH OF P2V-7 AT 125

400'

300'

200'

100'

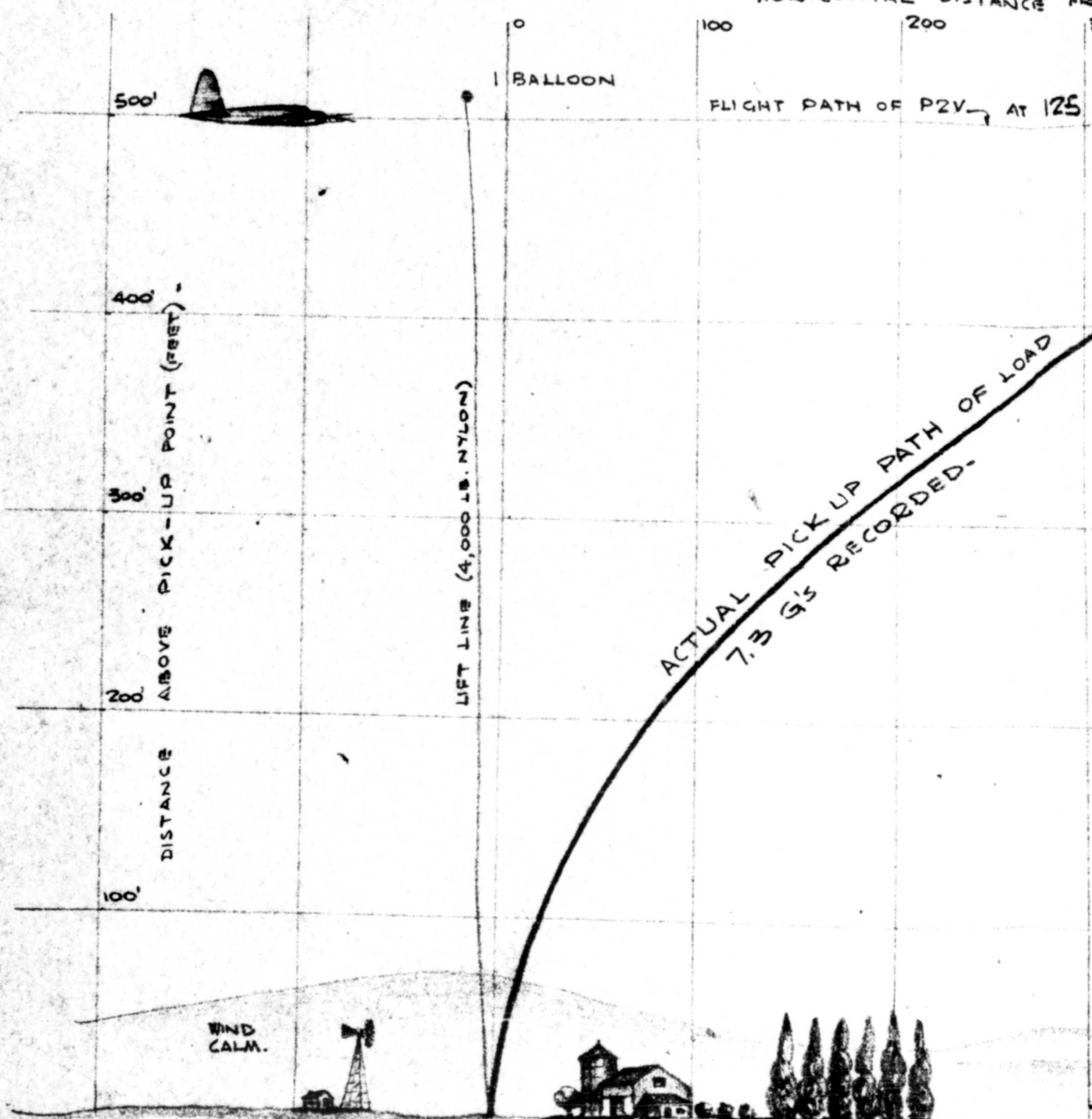
DISTANCE ABOVE PICK-UP POINT (FEET)

LIFT LINE (4,000 LB. NYLON)

ACTUAL PICK UP PATH OF LOAD  
7.3 G'S RECORDED.

WIND  
CALM.

LOAD  
200 LB. DUMMY.



KEYHOOK.

URE.

DISTANCE FROM PICK-UP POINT. (FEET).

300

400

500

AT 125 KNOTS.

LOAD

SIZE OF PHOTOGRAPH

PICKUP SK 13,  
22 NOV., 1954.  
PHOTOGRAPHED  
BY CAMERA II,  
64 FRAMES / SEC.

250 FT.

COMPUTED  
STABILIZED ALTITUDE  
OF LOAD. (6,000  
FT. FROM PICKUP)

175 FT.

COMPUTED LOW POINT  
OF LOAD PATH  
(2,400 FT. FROM PICKUP)

GRID IS DRAWN IN PLANE OF LOAD FLIGHT PATH,  
BUILDINGS, TREES, AIRCRAFT.

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### COMPARATIVE "G" LOADS, PICK-UP vs PARACHUTE

Full scale pick-ups produced "G" loads ranging from 5.0 to 10.2 G's (most of them were approximately 7.5) with maximum duration of less than  $\frac{1}{2}$  second.

These are well within the physical loads which a human can withstand.

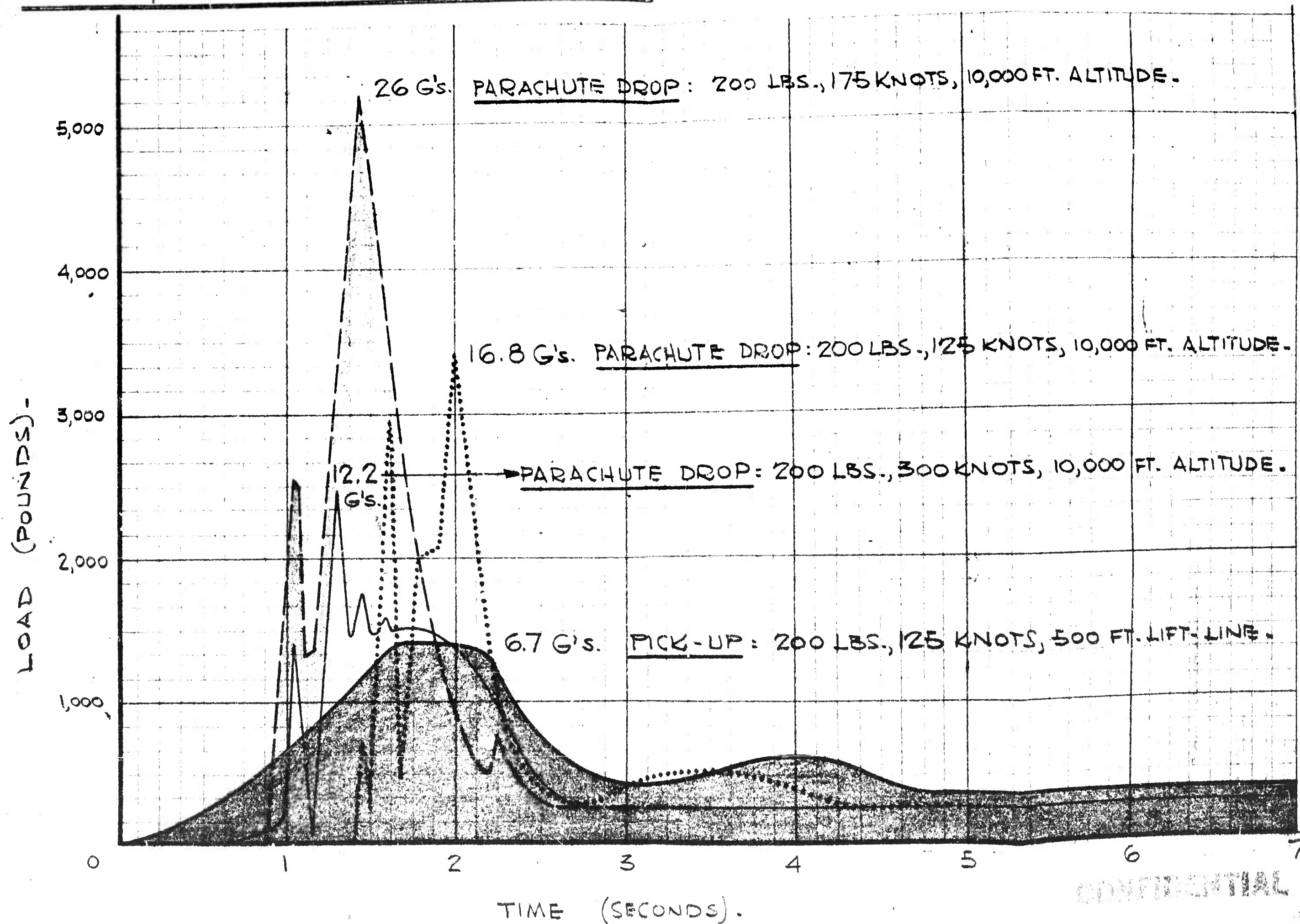
This is graphically demonstrated by accompanying direct comparison of SKYHOOK pick-up load curve and those of several typical parachute jumps .....

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REPORT TITLE HIGH-PERFORMANCE AIRCRAFT PICK-UP.

PARACHUTE VS PICK-UP G's.



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REPORT No. B (I) Nonr.1126(00). DATE 15 April, 1955. PAGE 17.

REPORT TITLE HIGH-PERFORMANCE AIRCRAFT PICK-UP, SKYHOOK.

### CONCLUSION

The SKYHOOK technique has proven that it can be used for full-scale pick-up work with operational type aircraft.

This technique has demonstrated the important advantages that it can :

1. Perform reliably
2. Be carried out swiftly
3. Be accomplished with only one aircraft (large or small)
4. Does not require much equipment or training.

## RECOMMENDATION

---

For operational service, pick-up equipment should be in KIT FORM so that where desirable operation can be controlled from the rescue aircraft. (Party being picked up would have only to proceed to bottom of lift-line and get into harness or bag.)

There would also be cases, however, where control of the equipment from below would be preferable (such as on shipboard).

Accompanying sketches indicate form in which such KITS are conceived and can be operated under various types of conditions .....

RECOMMENDATION continued  
on Page 23.

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REPORT NO. B(I)NOR 1126 (00) DATE 15 APRIL 1955 PAGE 19.

REPORT TITLE HIGH PERFORMANCE AIRCRAFT PICK-UP, SKYHOOK.

TYPE-A KIT.

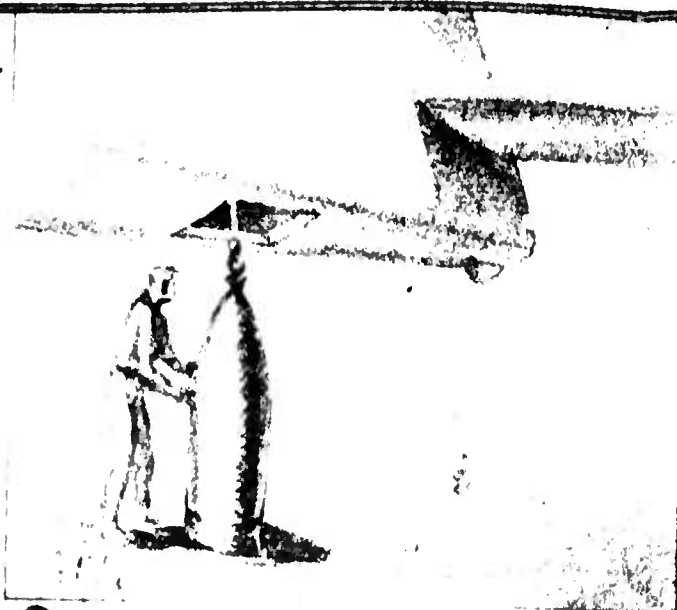
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TOTALLY AIR-OPERATED KIT FOR USE WHERE QUICKEST FORM OF PICKUP IS ESSENTIAL.

PRELIMINARY EXPERIMENTS IN RELEASE OF FULLY-INFLATED BALLOONS FROM IN-FLIGHT AIRCRAFT (125 KNOTS) HAVE BEEN REPEATEDLY SUCCESSFUL, THEREBY PROVING THE FEASIBILITY OF THIS PROPOSAL.

BECAUSE ITS MASS IS SO SMALL, BALLOON STANDS STILL IN AIR VIRTUALLY INSTANTANEOUSLY UPON RELEASE, THUS AVOIDING SUBJECTION TO STRONG AIR FORCES.

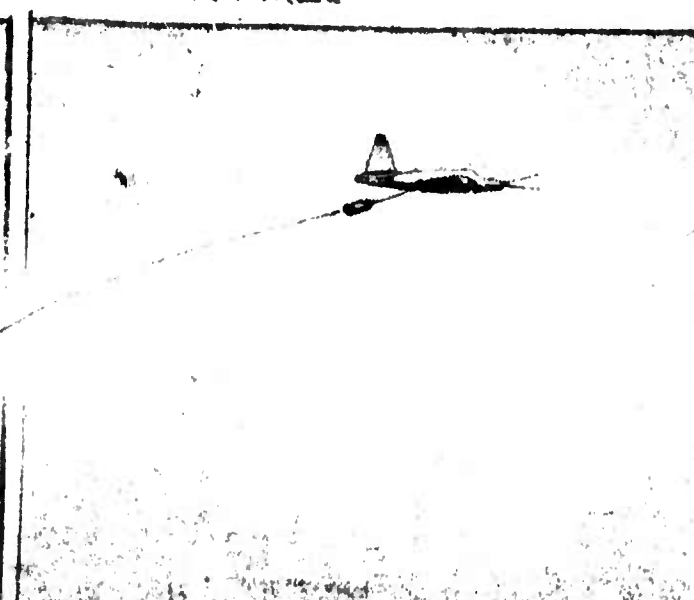
INERTIA OF LIFT-LINE IS ALSO NEGLIGIBLE EXCEPT AT BOTTOM WHERE HARNESS (OR BAG) IS ATTACHED. THIS IS ELIMINATED BY USE OF SMALL PILOT-PARACHUTE WHICH SWINGS INTO ACTION AS SOON AS BALLOON IS RELEASED FROM AIRCRAFT.



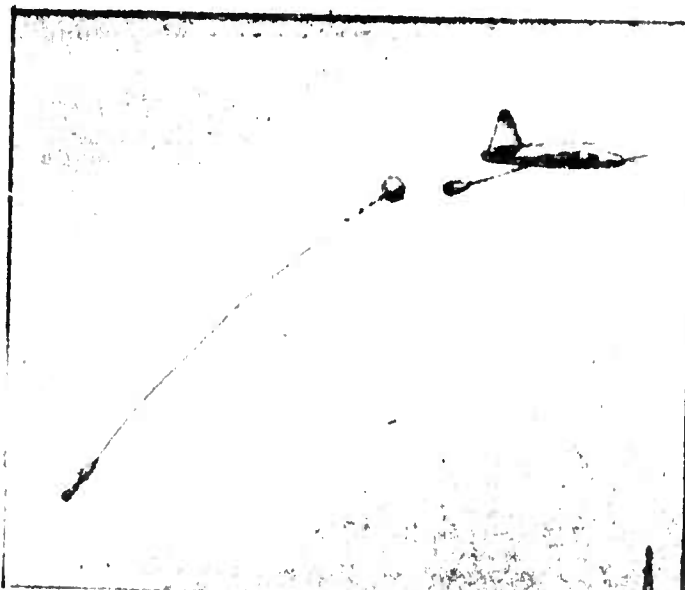
① LOADING KIT(S).  
(ESTIMATED WEIGHT: 30 LBS.)



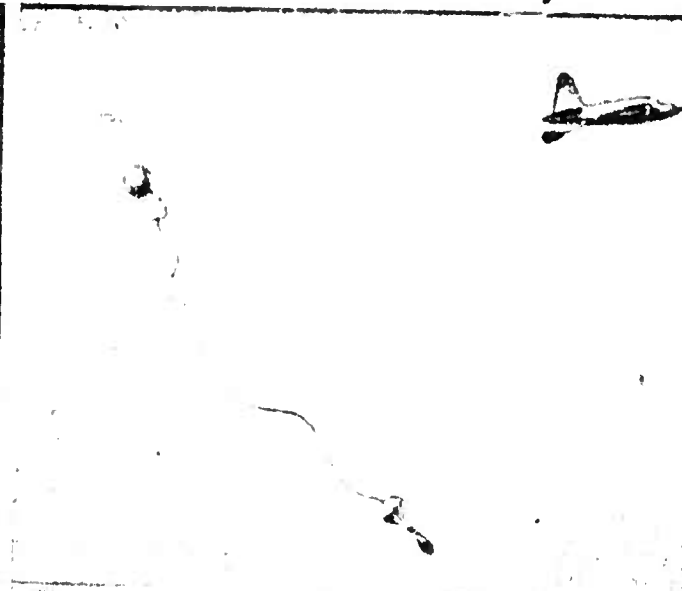
② STREAMING LIFT-LINE.



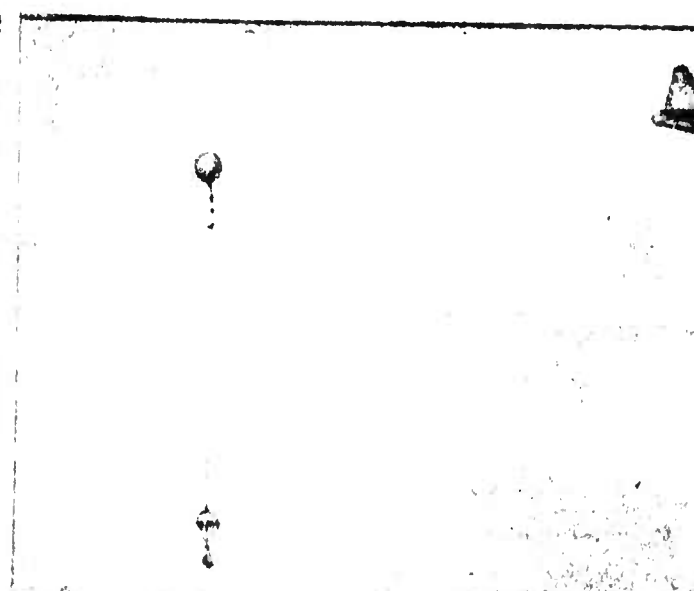
③ STREAMING BALLOON IN CONTAINER.



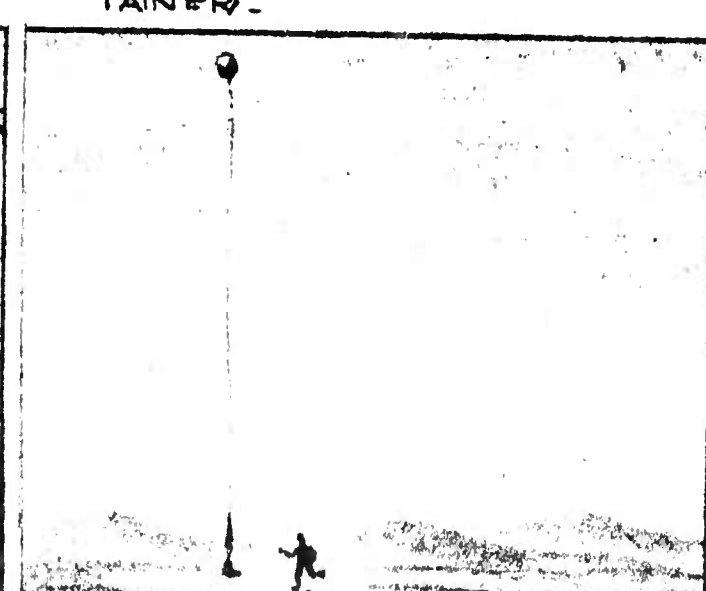
④ RELEASING BALLOON FROM CONTAINER. (SEE ABOVE NOTE.)



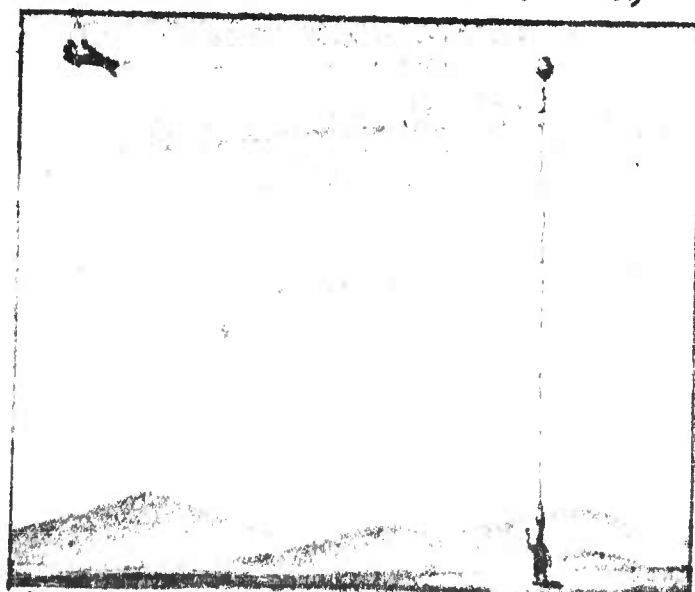
⑤ SMALL PARACHUTE ABSORBS INERTIA OF HARNESS.



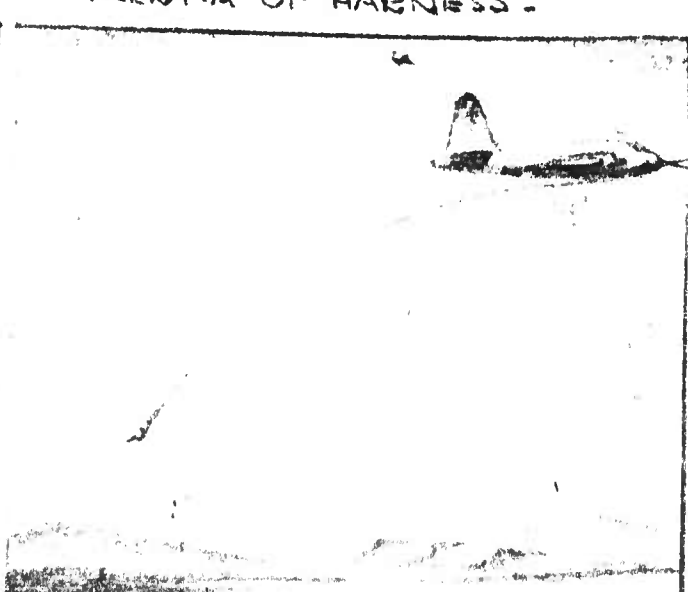
⑥ LIFT-LINE DESCENDING.  
(CONTAINER PULLED INTO AIRCRAFT).



⑦ PROCEEDING TO FULLY RIGGED LIFT-LINE. (EASY TO FIND).



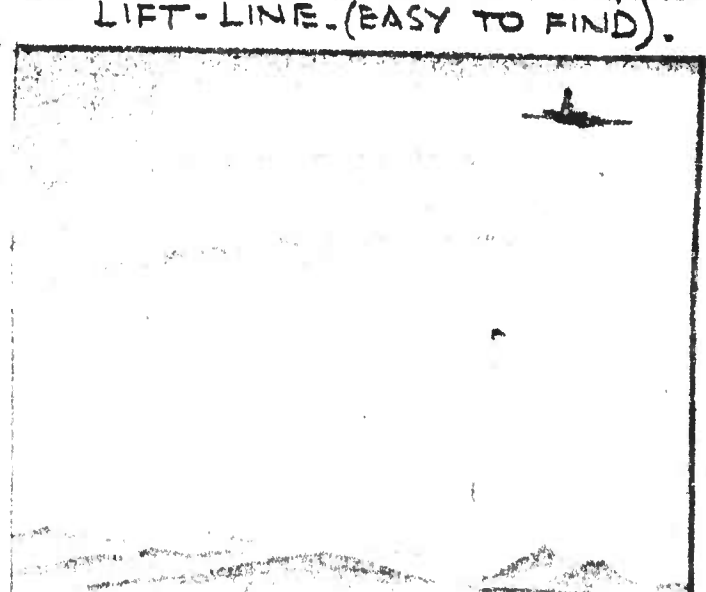
⑧ GETTING INTO BAG (OR HARNESS).



⑨ PICKING-UP.



⑩ HULLING IN.



⑪ RETURNING TO BASE ---  
(WITH ALL EQUIPMENT)



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REPORT TITLE HIGH-PERFORMANCE AIRCRAFT PICK-UP, SKYHOOK

TYPE-B KIT.

AIR SUPPLIED KIT FOR USE WHERE TIME PERMITS OR KIT MAY BE STORED FOR LATER USE

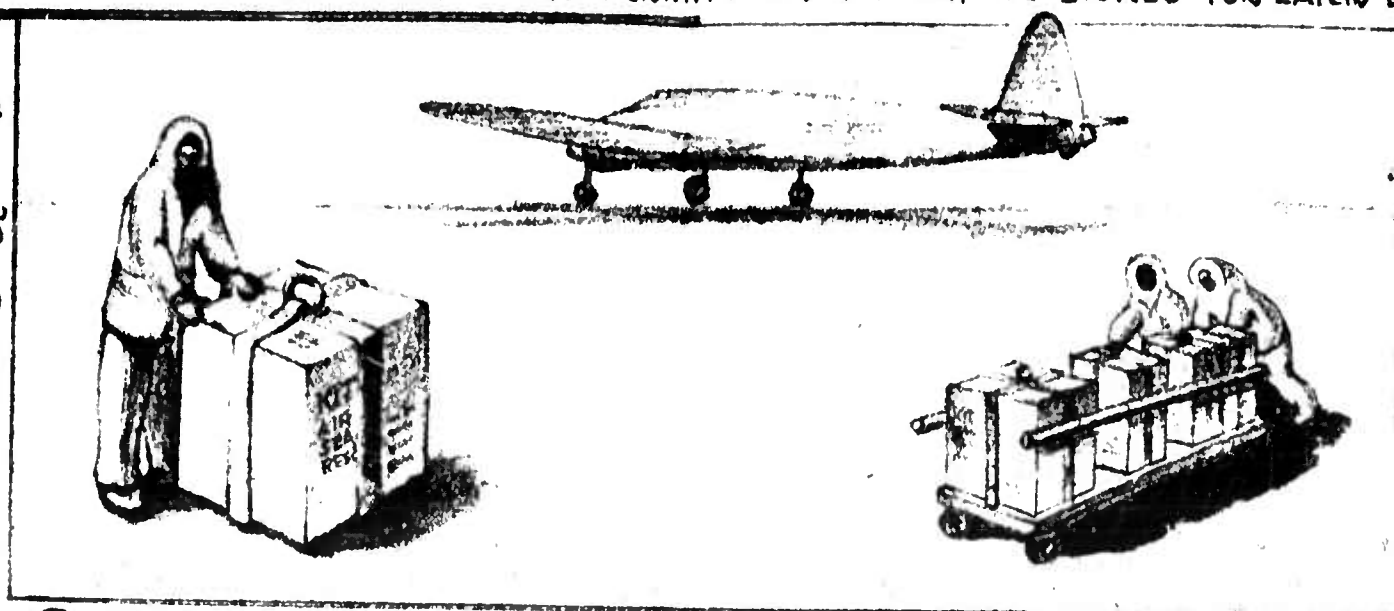
EQUIPMENT FOR THIS KIT IS ESSENTIALLY REFINEMENT OF UNITS USED DURING THE OPERATIONAL FEASIBILITY TESTS.

COMPLETE KIT WILL CONTAIN BALLOONS, HELIUM CYLINDERS, CONTROL VALVE AND MANIFOLD, LIFT-LINE COMPLETE WITH "KNOTS", BUFFERS, HARNESS (OR BAG) AND ASSOCIATED HARDWARE.

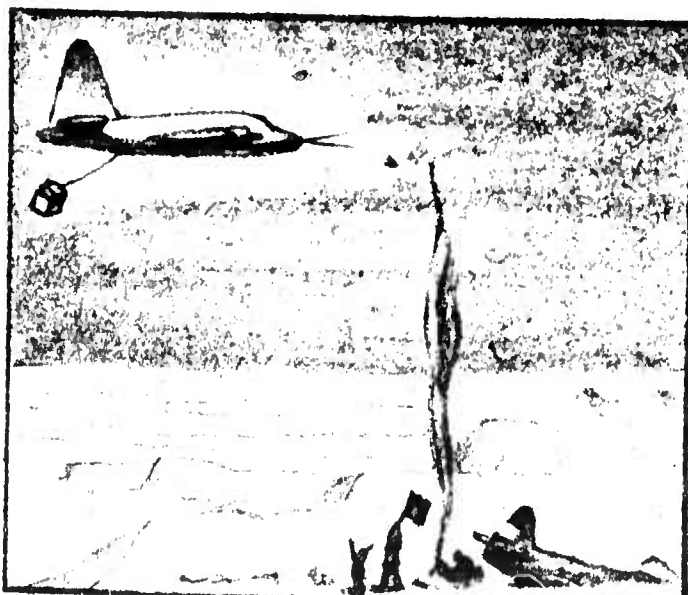
DROP-CHUTE WILL CLIP ON OUTSIDE OF KIT.

KITE-KITS SHOULD ALSO BE MADE UP FOR USE IN STRONG WINDS.

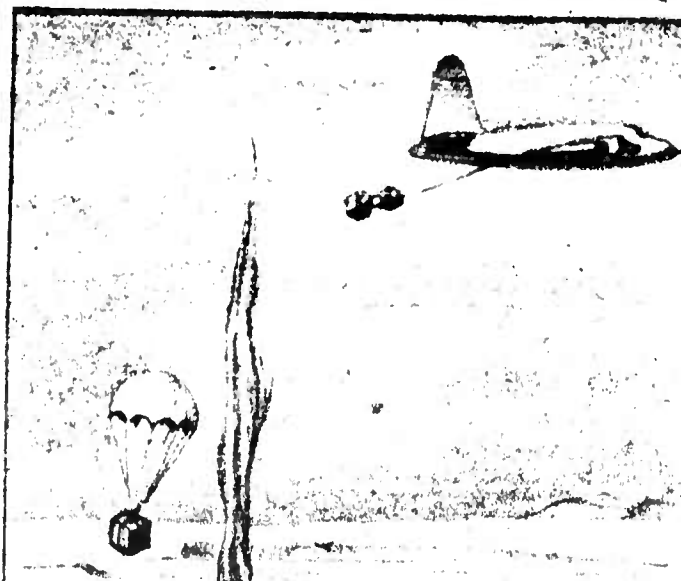
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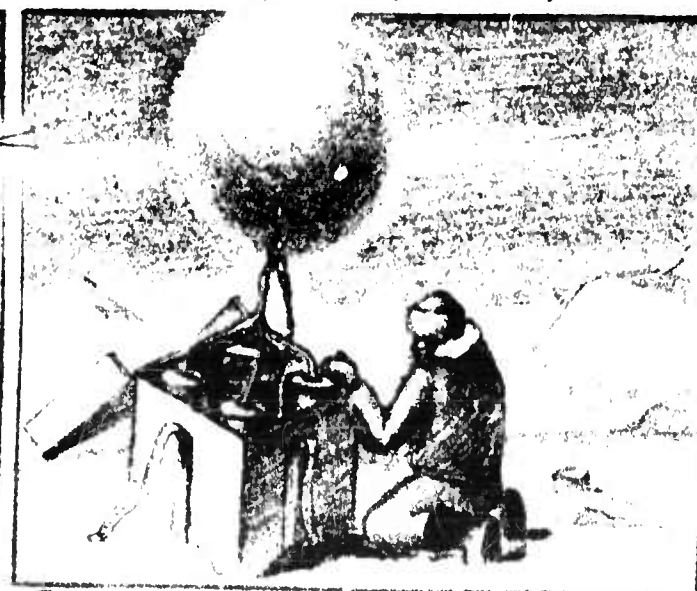
① KIT DIMENSIONED TO FIT THRU HATCH OF ANY AIRCRAFT THAT MAY BE ASSIGNED TO OPERATIONAL PICK-UP WORK (ESTIMATED 20"W, 30"L, 30"H, 150 LBS.)



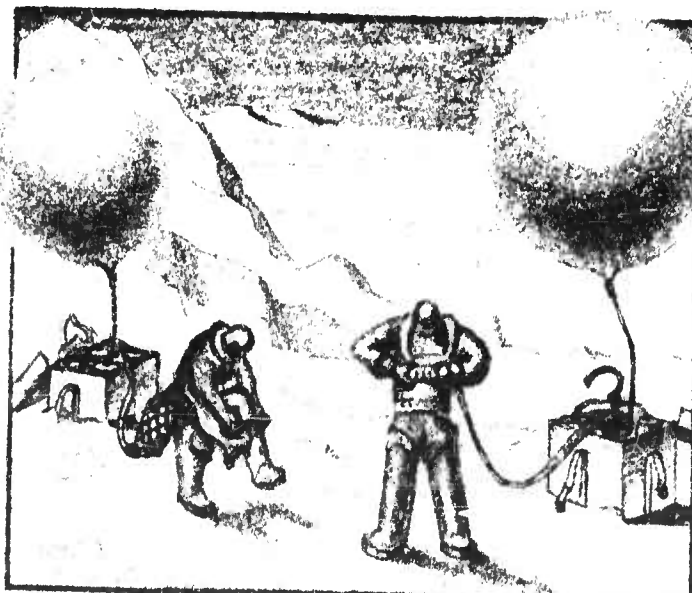
② EJECTING KIT.



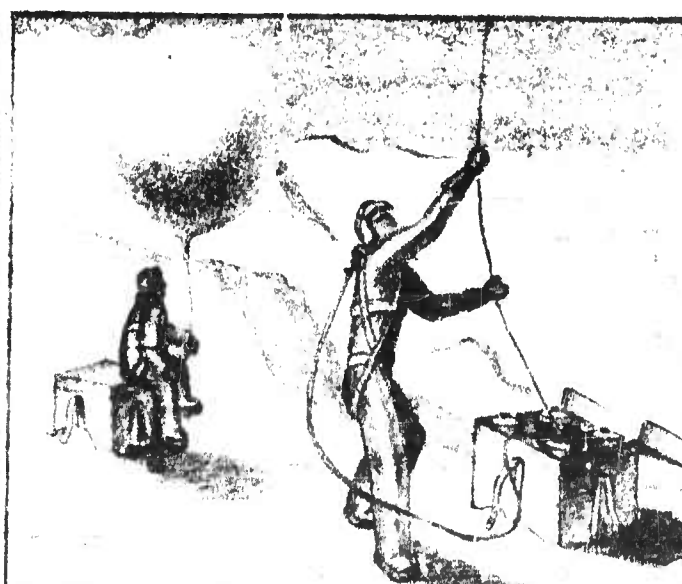
③ PARACHUTE DESCENT.



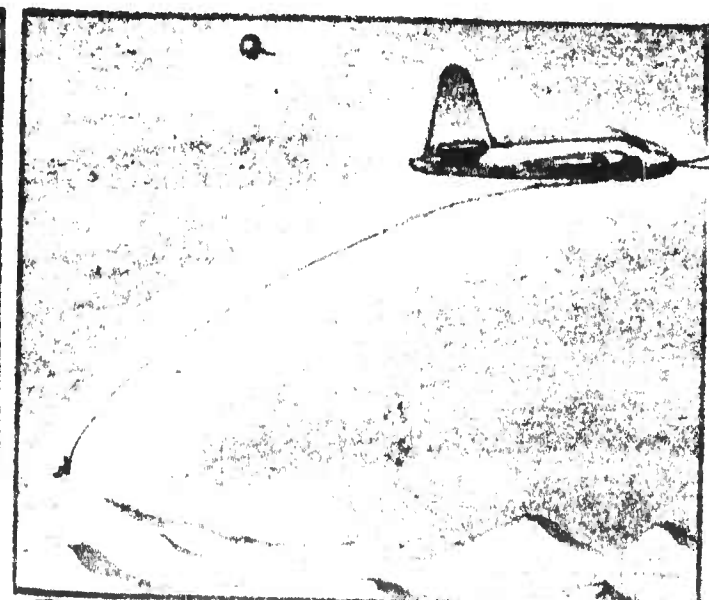
④ SINGLE-OPERATION INFLATION.



⑤ INTO HARNESS (OR BAG), BALLOON & LIFT-LINE ALREADY ATTACHED.



⑥ PAYING OUT LIFT-LINE.



⑦ PICK-UP & HAUL IN (MAXIMUM TOTAL OF 3 MINUTES PER MAN).

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REPORT TITLE HIGH PERFORMANCE AIRCRAFT PICKUP, SKYHOOK  
TYPE AOR B KIT FOR AIR-SEA RESCUE OPERATIONS.

- ① AIRCRAFT FLIES TO LEEWARD  
OF RAFT, DROPS CORK-FLOATED  
NYLON LINE WITH BUOY AND  
FLOATING KIT ON OPPOSITE ENDS.

RAFT DRIFTS INTO LINE.



- ④ PICK-UP, HAUL IN  
AND RETURN TO  
BASE.

- ② SINGLE-OPERATION  
INFLATION.  
IF VERY WINDY, KITE-  
KIT IS DROPPED.

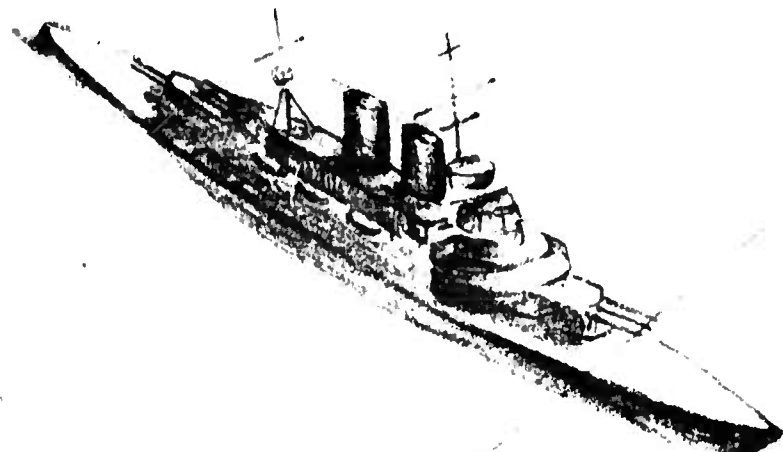
- ③ INTO HARNESS.

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REPORT No. B (I) NONR 1126(00). DATE 15 APRIL 1955 PAGE 22.

REPORT TITLE HIGH PERFORMANCE AIRCRAFT PICK-UP, SKYHOOK  
TYPE B KIT FOR SURFACE VESSEL OPERATIONS.



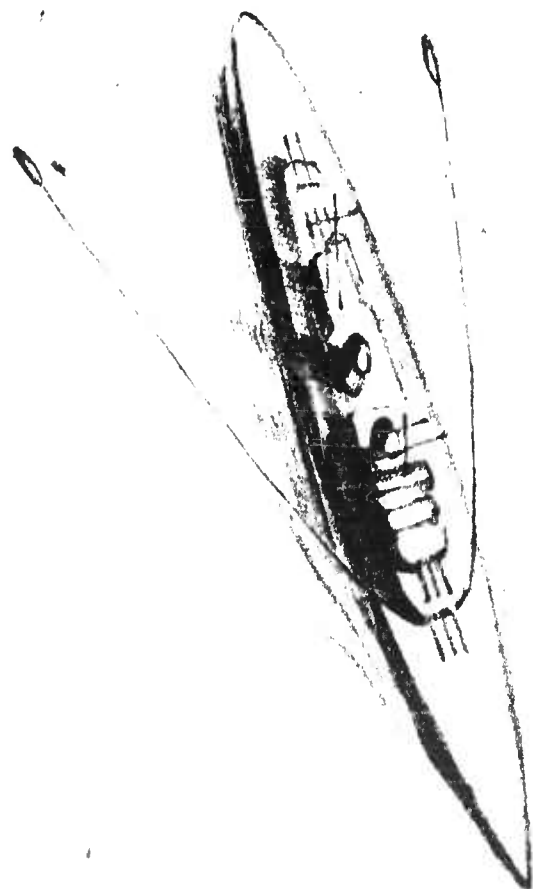
① (ABOVE)

FOR DELIVERY OF MESSAGES,  
NYLON LINE IS FLOWN LOW  
OVER BOW OF SURFACE VESSEL.

② (RIGHT)

BOTH ENDS OF LINE ARE  
ATTACHED TO IDENTICAL  
FLOATS, ONE CONTAINING  
PAPERS.

WHEN DROPPED, LINE  
STREAMS AFT FROM BOTH  
SIDES OF VESSEL, CONTAINERS  
ARE READILY HAULED ABOARD.



③

MESSAGES OR PERSONNEL  
CAN BE PICKED UP FROM  
VESSEL.

BALLOON IS USED BY SHIP  
TRAVELLING WITH WIND.



④ (RIGHT)

WHEN SURFACE VESSEL  
IS TRAVELLING TO WINDWARD,  
KITE MAY BE USED.



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REPORT TITLE HIGH-PERFORMANCE AIRCRAFT PICK-UP, SKYHOOK.

RECOMMENDATION continued.

Development of operational equipment in final form is largely a matter of refining the test units which have proven their ability to work but can now be brought into better relative proportion as a result of the test experience gained.

The form of the above-outlined KITS, along with standardized hardware (yoke, winch, etc.) for use in the aircraft, should be established and tested.

Tests should include large number of dummy pick-ups and simulation of all possible operational situations before personnel pick-ups are accomplished.

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I N D E X, SECTIONS II, III & IV cont'd.

S U B J E C T

P A G E

SECTION IV

This Section consists of a 16mm Kodachrome motion picture film taken during Operational Feasibility Tests at NAAS El Centro, California.

Running time is approximately 30 minutes.

Material illustrated includes the following:

1. A typical SKYHOOK pick-up operation.
2. Yoke installation on P2V.
3. Winch, crook, snatch-block, clamp-knot, auxiliary winch.
4. Loads and fittings  
(Sand bags, dummies, Ex-line tensiometer, Brinell blocks).
5. Lines, markers, knots  
(Tower testing, buffers vs windshield).
6. Balloons and gas
7. Pilotage  
(Yoke camera, visibility, vertical and horizontal latitude of intercept).
8. Photographic equipment
9. Paths of picked-up loads